1. Title:
Using Current IPM Technology and New Communication Technology to Prevent Pome and Stone Fruit Infestation by Codling moth and Oriental Fruit Moth

2. Project Leader(s):
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4. Abstract:
Codling moth (CM) and oriental fruit moth (OFM) have increasingly challenged fruit IPM programs since 2000. There is a zero tolerance for worms in processing fruit diverting it to juice with a $1500 per acre loss in fruit value for the grower. Accurate timing of appropriate control options is necessary to achieve 99% worm control in an IPM system. This project implemented insect monitoring technology including sex pheromone traps and insect developmental degree-day models to schedule control actions on farms. This project increased adoption of this technology by growers and consultants resulting in minimizing pesticide inputs and economic losses of rejected fruit loads.

5. Background and Justification:
Apple IPM programs are being challenged by codling moth (CM), oriental fruit moth (OFM), and lesser appleworm (LAW) that were historically in the background and controlled by broad spectrum materials meant for control of other pests. These pests in the Lepidoptera Order are commonly referred to as "internal leps," as they feed on the flesh of fruit. Management of this pest complex is rated as high priority in the IPM Fruit Commodity and LOF Advisory Committee priority lists. There is a zero tolerance for these larvae in most fruit markets resulting in intensive control strategies in high pressure orchards. Many growers responded to the high economic risk of wormy fruit by returning to a broad-spectrum cover spray program that might not be necessary based on pest pressure in all orchards.

IPM methods have been developed through research to manage these pests bringing opportunities for extension programs to reduce the economic risk of fruit infestation, and minimize the risks of pesticides used. 1) Pheromone traps have been used globally to monitor first emergence of male moths, and set biofix (first flight) to start a degree-day model that predicts first egg hatch and precisely schedules insecticide applications. It is necessary to kill the newly hatched larvae before they are sheltered in the flesh of the fruit. 2) Mating disruption is a new technology which prevents the males from finding the females to mate, reducing the population. But in most cases insecticide sprays must still be incorporated in this technology due to the migration of mated females into the disrupted blocks to lay eggs. Other than looking for damaged fruits, the only way to determine the need and timing for sprays in these systems is trapping in areas without mating disruption to monitor flight and predict larval development using established degree day models.

As these pest pressures develop (as they have in other apple growing regions) growers and consultants will need to adjust pest management activities to include strategies for control. The first step in management is to identify the primary species on farms by identification of larvae in fruit at harvest the previous season. The second step is to time insecticide and pheromone applications properly for control. These 2 steps can be supported with the establishment of a regional pheromone trap network with results published on the web, in newsletters, faxes, and emails. Consultants and field reps are already stretched thin with the number of traps they can maintain and a supplemental trap network can assist them without increasing the costs to growers and consulting industry. Providing these pest status reports can fine-tuning pest management inputs for better control, reduce spray costs by $1000's on each farm, and minimize the use of organophosphates, and pyrethroids.

In 2005, CM was identified as the key pest in >65% of the 95 infested loads. This is a significant increase over previous years when the primary pest was OFM. Various trap types are being deployed on a limited basis in the state. Trapping studies for CM have identified advantages and disadvantages of various trap shapes, sizes, and colors. The current recommendation of a weekly cumulative CM trap catch threshold of 5 moths per trap was developed using a Pherocon IIB trap (Riedl, Croft, and Howitt, 1976). But Knight, et.al. found that more CM adults are trapped in Pherocon VI (Delta) and IIB traps than 1CP wing traps. Since there are some advantages to the Pherocon VI (Delta) trap and 1CP traps, trap catch efficiency was compared to IIB to see if we could demonstrate a difference between traps and move toward a more standardized trapping program.

6. Objectives:

1. Increase the use of pheromone traps and degree-day models to determine need and timing of controls.
2. Standardize trapping procedures used to make management decisions for CM.
3. Optimize control timings and decrease economic risk of fruit infestation by internal lep larvae.

7. Procedures:

1.a. A workshop in the Spring of 2006 as well as summer field meetings were conducted to teach growers and consultants about internal larva identification, biology, monitoring and trapping, and control strategies for managing CM/OFM.

1.b. Pheromone traps for each of CM (2), OFM (2), and LAW (1) were installed in each of 25 locations in Niagara, Orleans, Monroe, and Wayne Counties with a mix of high and low risk pressure orchards. Trap catch was recorded and traps cleaned weekly. Pheromone lures were replaced at 4 week intervals. Trap data was reported to growers and consultants in emails, faxes, and newsletters. Biofixes and trap catch data were used with degree-day models to determine optimum timing for insecticides and mating disruption pheromones. Trap counts were reported on the internet by linking to a GIS-based map of New York, each location linked to an Excel file to display trap data for each pest in that specific location. This information was posted on the web sites for LOF (www.fruit.cornell.edu/lof/trapreports/index.html) and linked to NEWA for the degree day calculations.

Growers were invited to join the trap network to generate regional trap data for these pests. Two growers learned to maintain traps, identify trapped insects, and report counts to the Extension educator by fax or email.

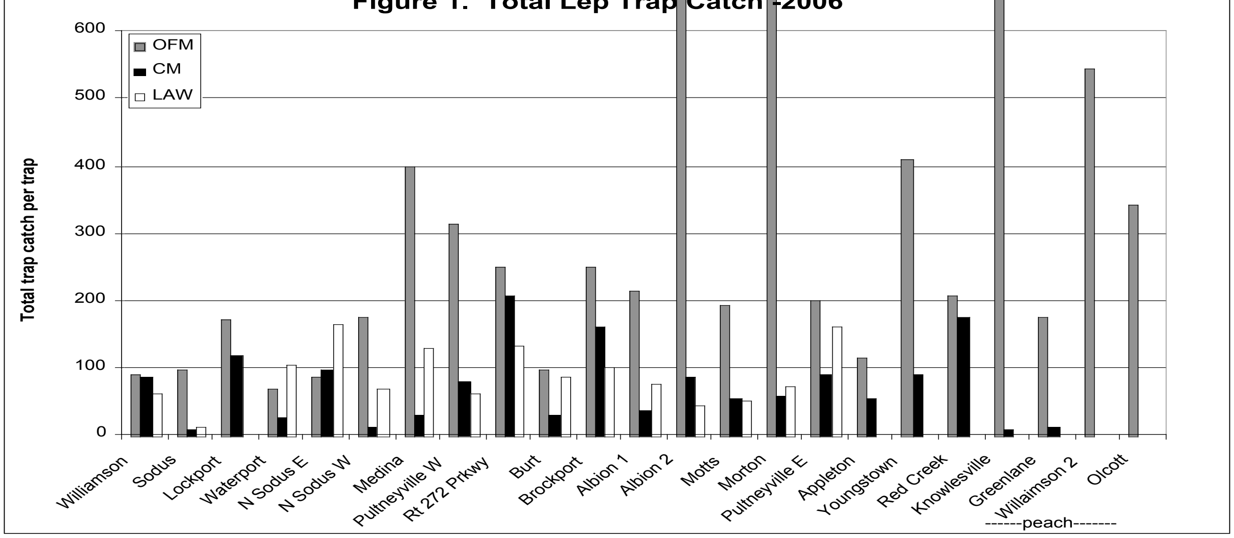
2. In 2 moderate-high pressure plots, 3 trap types (Pherocon IIB, Pherocon VI Delta, and 1CP) were compared relative to each other to determine the best fit for the recommended 5-7 moth threshold for CM. Two traps of each type were hung in random order in each 10 acre orchards, and rotated in position weekly. CM traps were hung at 2 m high. Traps were placed in randomly selected positions and moved twice per week. Counts were totaled for each trap, and data analyzed (ANOVA) for differences among trap types and trap position in the orchard.

8. Results and Discussion:

1a. Sixty growers and consultants who had internal lep infested fruit in 2005 were invited to learn about the benefits in trapping in making decisions about control options and timing of these pests. This project had the potential to keep 28,000 acres of apples, 1000 acres of peaches, and 700 acres of pears worm free. Eleven growers and 8 consultants/field reps who represent 10,000 acres attended the workshop and all indicated they learned something that would help them manage this pest complex in 2006. The growers and consultants indicated that the insect identification portion of the workshop was invaluable to help them determine the target for 2006 and identify the pest in infested fruits for planning 2007 controls. Two attendees reported they would be using degree-day models more to determine spray timing. Due to our efforts over the past two seasons, all consultants and field reps are running at least some traps on their clients' farms to better identify the pests and spray timing.

1b. The trap network was successful for demonstrating to growers the potential impact of this pest complex on their farm. The growers in the project learned which of the three pests in the complex were the primary problems based on trap data. The counts were reported to the growers with recommendations on control timings based on trap catches. As shown in Figure 1, OFM continues to be present in higher populations than CM and LAW on most farms. But on many farms, CM numbers are increasing and are almost equal to trap catch for OFM indicating a serious population. Of the farms in the trap network, 15 (65%) of 23 farms had more than 50

Figure 1. Total Lep Trap Catch -2006

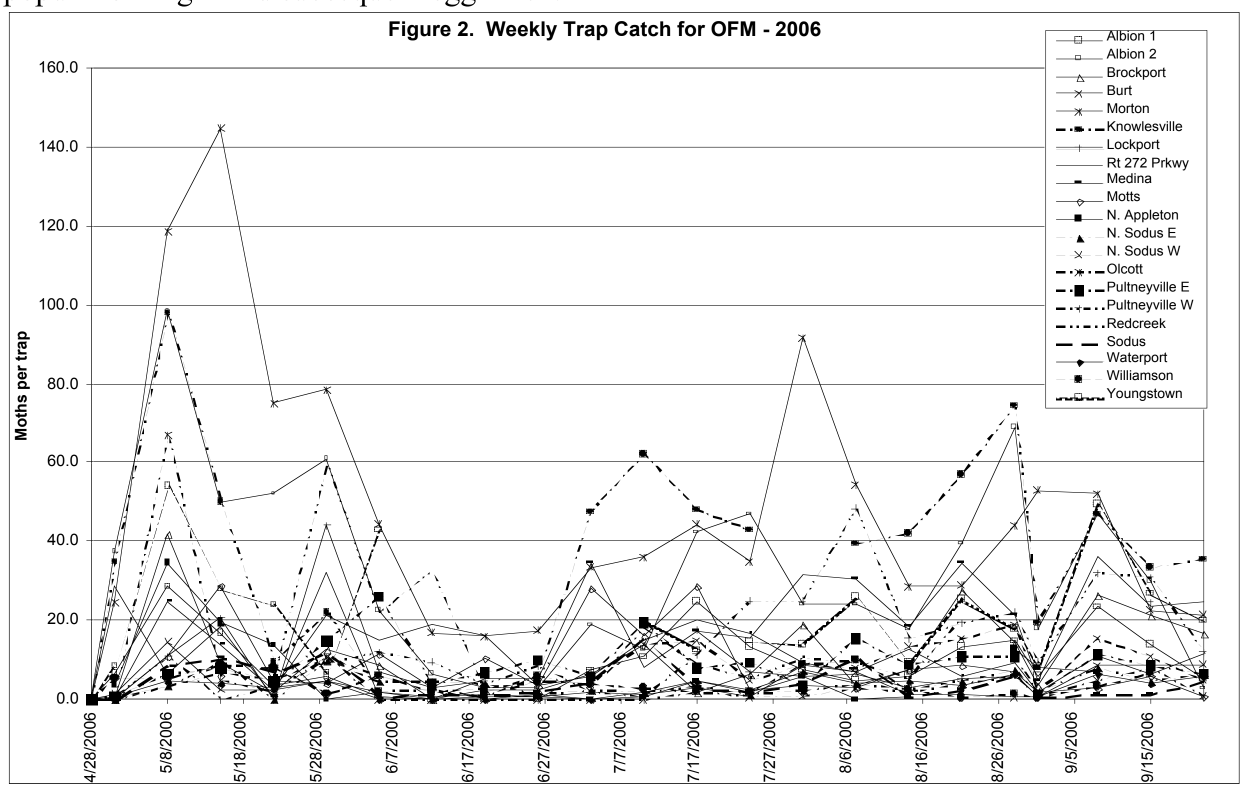


CM moths per trap per season caught in 2006. In 2005, 7 (47%) of 15 sites caught more than 50 CM moths per trap per season signaling an increase in pressure in the region.

The trap network was published on the website www.fruit.cornell.edu/lof to distribute the detailed trap information to extend the information on a regional basis. The website was updated on a weekly basis. A counter will be added to the web pages for the 2007 season if funding for the project continues.

Two growers agreed to maintain their own traps and email the counts to the extension educator. The growers learned how to identify the actual moths in the traps and discriminate between the pests and other moths that were also attracted to the traps or pheromones. The growers had the counts emailed to be included in the trap network website and called for recommendations on actions required. It went smoothly until sweet cherry and peach harvest began. We learned that growers who are also busy with their own marketing are not able to maintain trap data consistently once marketing season begins. Having the tap network in place allowed some assistance in maintaining these traps when the growers were not able to dedicate the time.

The trap catches, by date and farm, are included in Figures 2-3 to show the variability of trap catch peaks for each location during various parts of the season. These differences among orchards suggest that individual farm trapping is essential to identify the specific pests in the complex that threaten fruit infestation and optimize spray timing. This information is currently in a database with degree day accumulation from first trap catch of the season and the beginning of subsequent generations for the season. This data will be analyzed this winter to determine how closely recommended degree-day timing models for CM and OFM match the actual population flight and subsequent egg hatch.



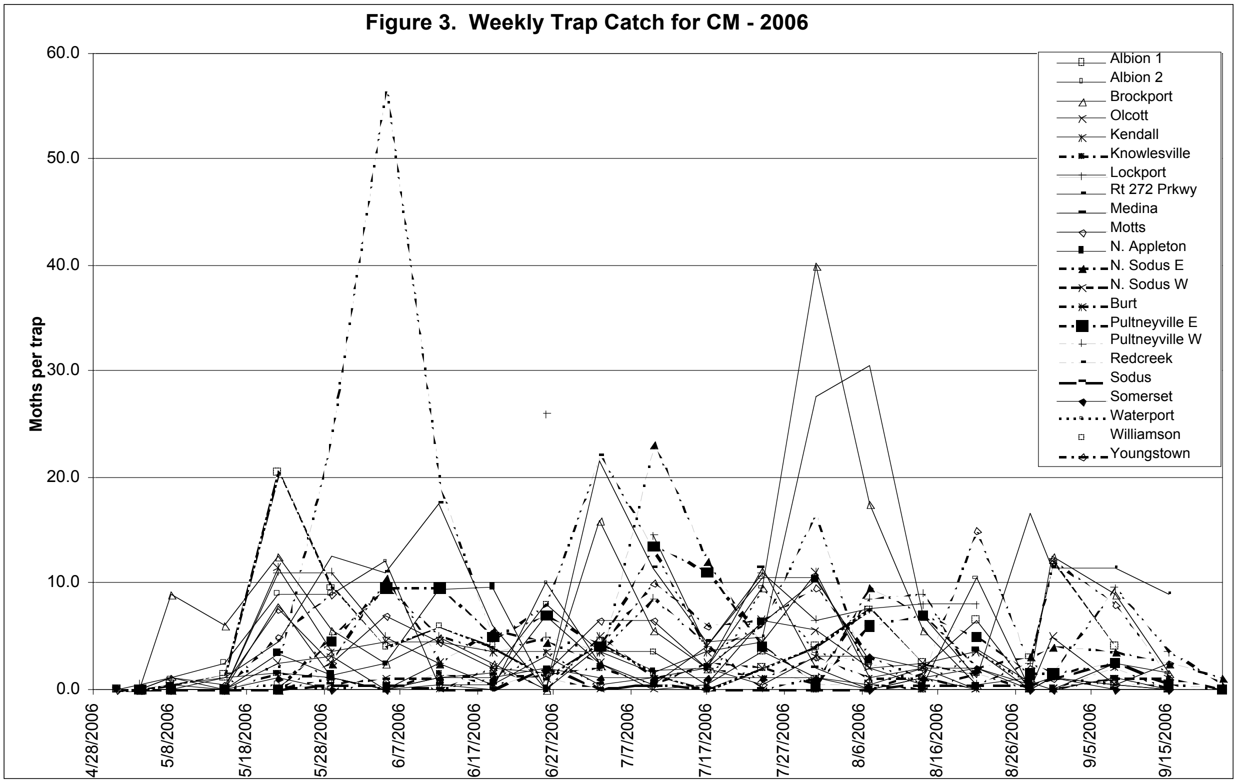


Figure 3. Weekly Trap Catch for CM - 2006
Moths per trap
60.0
50.0
40.0
30.0
20.0
10.0
0.0
4/28/2006
5/8/2006
5/18/2006
5/28/2006
6/7/2006
6/17/2006
6/27/2006
7/7/2006
7/17/2006
7/27/2006
8/6/2006
8/16/2006
8/26/2006
9/5/2006
9/15/2006
Albion 1
Albion 2
Brockport
Olcott
Kendall
Knowlesville
Lockport
Rt 272 Prkwy
Medina
Motts
N. Appleton
N. Sodus E
N. Sodus W
Burt
Pultneyville E
Pultneyville W
Redcreek
Sodus
Somerset
Waterport
Williamson
Youngstown

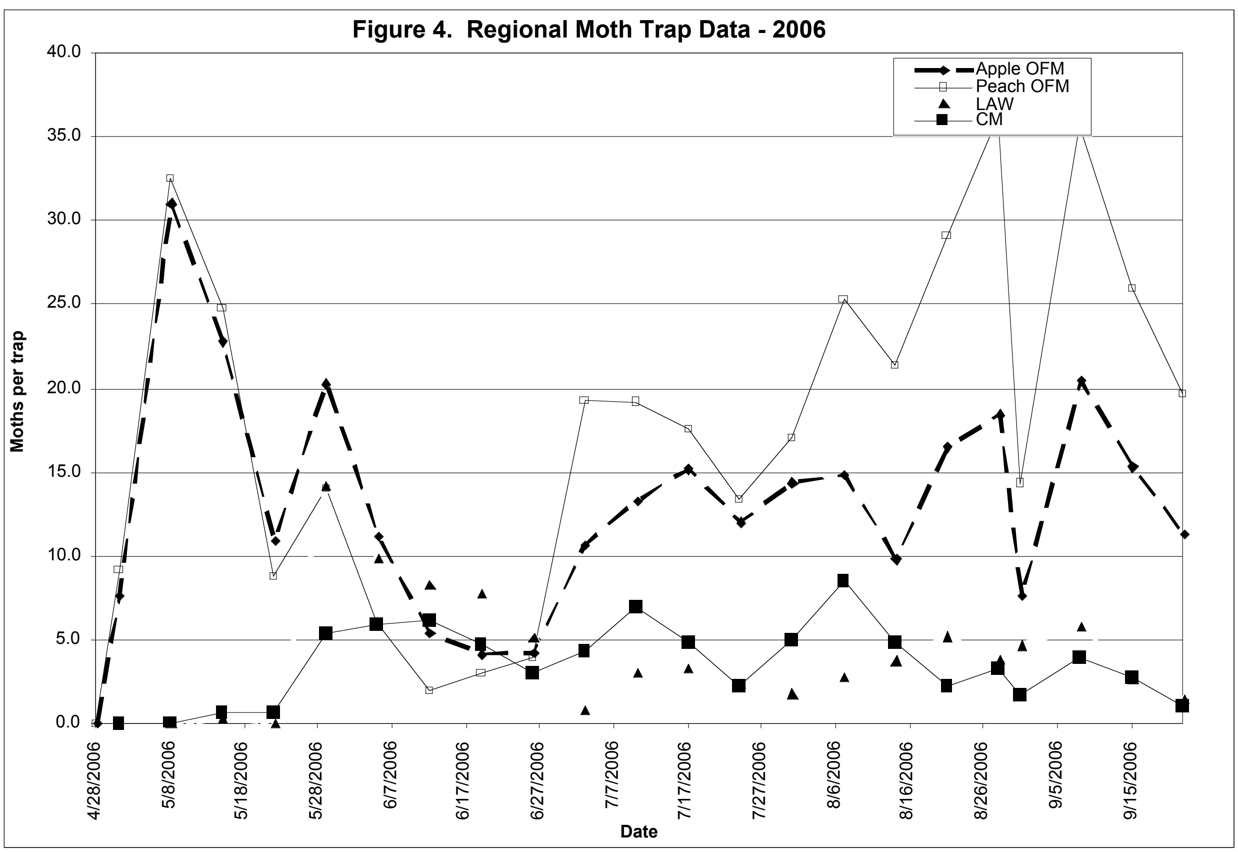


Figure 4. Regional Moth Trap Data - 2006
Moths per trap
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4/28/2006
5/8/2006
5/18/2006
5/28/2006
6/7/2006
6/17/2006
6/27/2006
7/7/2006
7/17/2006
7/27/2006
8/6/2006
8/16/2006
8/26/2006
9/5/2006
9/15/2006
Date
Apple OFM
Peach OFM
LAW
CM

The average trap counts across the Lake Ontario Fruit Region are shown in the Figure 4. The regional data shows the first trap catch for CM on average for the region occurred on May 15. However, one orchard had 8 moths per trap caught between May 4 and May 8 resulting in a biofix one week earlier than the average. Other orchards had first trap catch recorded as late as May 28. This is a function of high vs. low population of CM in orchards and again highlights the importance of on-farm monitoring with pheromone traps.

Harvest evaluations were conducted in orchards to estimate fruit infestations. Results are shown in Table 1. We collected 50 apples from each of 5 randomly selected trees of a specific variety. Eleven orchards were categorized as having high populations of OFM or CM or both – of these orchards, 6 had fruit damage at harvest due to internal lep pests. The remaining six orchards, where harvest evaluations were conducted, were categorized as moderate to low pressure orchards; none of these orchards had any detectable damage from lep pests. Spray records will be compared from the 6 high pressure orchards with damage to the 5 orchards with no damage to detect any trends in control applications.

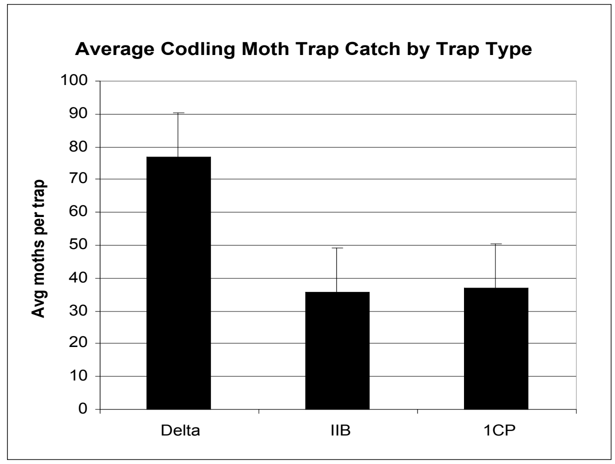
Table 1. Harvest evaluations for apple orchards in trap network

			% insect damage					
Location	Date	Variety	IntLep*	OBLR-OW	OBLR-S	AM	sting	TPB
Albion 1	29-Sep	Jonagold	0	0	1.6	0	0	0
Albion 2	18-Oct	Idared	3.4	2	15	0.2	3.2	0.6
Brockport	5-Oct	Idared	7.6	0	10.4	0	4.8	0
Burt	3-Oct	Delicious	0	0	0.8	0	0	0.4
Lockport	10-Oct	Crispin	0	0	0	0	0	0
Medina	17-Oct	Idared	0.4	0	0.8	0	1.6	0
Morton	5-Oct	Idared	3.6	0	12	0	4	0
N Sodus E	13-Oct	Idared	0	0	0	0	0	0
N Sodus-W		G. Del	0			0		
Pultneyville 1	13-Oct	Idared	0	0.4	4.4	1.6	6	0
Pultneyville W	22-Sep	Monroe	0.4	0	5.6	0	0	0
Rt 272 x Parkway	5-Oct	Idared	0	0.4	4	0	0.4	0
Sodus	13-Oct	Idared	0	2.8	3.2	0	0	0.8
Waterport	29-Sep	Jonagold	0	0	0	0	0	0
Williamson	5-Oct	Jonagold	0.8	1.6	3.6	0	1.2	0
Youngstown	10-Oct	Idared	0	0	0	0	0	0
N Sodus-check	5-Oct	Delicious	12	0	0	79	0	0
Pultneyville W-check	22-Sep	20 Oz.	44	0	24	0	0	0

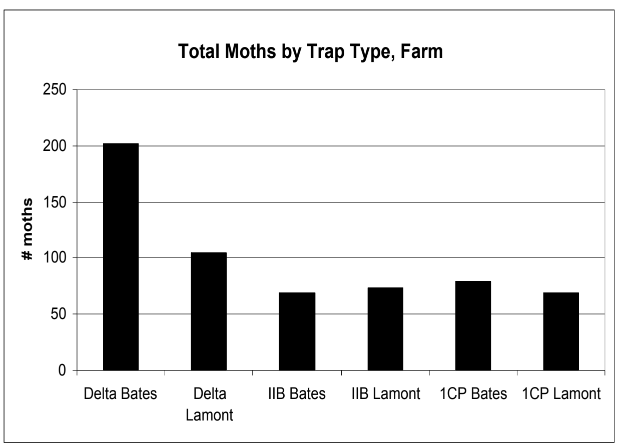
* IntLep=internal lep damage, OBLR-OW=overwintering obliquebanded leafroller, OBLR-S=summer brood obliquenbanded leafroller, AM=apple maggot, sting=1 bite less than 1/8 inch deep, TPB=tarnished plant bug

The spray records will be analyzed this winter for cost of control of this pest complex. Insecticides used will be classified by number of applications of organophosphates, pyrethroids, neonicotinoids, and insect growth regulators, etc. The economic impact of internal lep control on high-pressure blocks vs. low-pressure blocks will be measured.

2. The codling moth trap data for two sites was combined and analyzed using One-Way ANOVA. The Delta trap caught statistically more moths than the IIB and 1CP traps. Based on this analysis, if the CM threshold for controls is based on the IIB trap catch levels, then the Delta traps might be over estimating the population of codling moth in the orchard.



ANOVA analysis was done on individual orchard data. The Bates block had statistically significant differences in both position of trap in the orchard and in trap type, but there was no significant interaction. The Lamont block had no significant differences in position in the orchard or in trap type. However, it is important to note that the trap catch has peaks and lulls in flight based on the development of the generations of CM through the season. Therefore, data was analyzed using a limited data set which only included data during significant flight periods - with average trap catch over all traps equal to or greater than 1. There was no significant difference in trap type or position in the Lamont orchard, but there was significance difference in both trap type and position in the orchard in the Bates orchard as shown in Table 2.



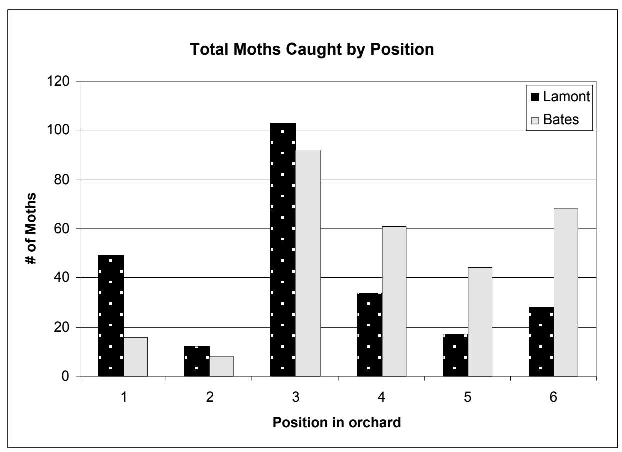


Table 2. Mean Trap catch for Trap Types in 2 Locations		
	Location	
Trap Type	Lamont	Bates
Delta	3.6	4.7 a
1CP	2.1	1.9 b
IIB	2.7	1.6 b

Given the differences in results between orchards, this test should be repeated for another season with 3 replicates of trap types in each of 3 orchards if funding is available.

Program Evaluation:

- This project increased the adoption of pheromone trapping and degree-day models for optimizing the use of insecticides for control of internal leps.
- The educational programs and trap network were successful in limiting a regional disaster by informing growers of critical times for control of OFM and CM. Pennsylvania growers lose $1M annually when more than 700 truckloads of fruit are rejected from processing and diverted to juice for the past several years. To assess regional levels of larval infestation of fruit at harvest, infested apples were collected at various receiving stations. The larvae were identified, and the total number of samples and number of growers was compared to previous seasons' records of infested loads. There were a total of 118 samples of infested apples collected at receiving stations and were identified as CM (50%), OFM or Law (44%). The number of loads with worms detected is still less than 5% of all loads delivered and included only 48 growers. This is a decrease from 59 growers in 2006.
- Trap network data will be summarized to determine predominant pests of concern for each farm. Trap counts, weather data, and spray records will be collated for each block to evaluate grower management decisions based on trap data, degree-day models, economics, and environmental impact of control choices. These specific results will be shared with growers in a special report in January.
- The trap network will be a valuable resource to assist producers using mating disruption technology to time supplemental insecticide protection during critical periods. Insecticides applications will be optimized for the best results.
- The CM trap test was not conclusive and should be repeated.
- More work is necessary to evaluate the use of the CM degree day developmental model for NY populations.

9. Project Locations:
Wayne, Orleans, Niagara, Monroe Counties of Western New York

Website Master – Craig Cramer, Horticultural Sciences Department, Cornell University.